FLUID-SEDIMENT DYNAMICS IN THE NEARSHORE

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LONG-TERM GOALS

The long-range goals of this program are to improve our understanding of the processes and physical mechanisms responsible for beach morphology changes and patterns of erosion and deposition in the nearshore zone.

OBJECTIVES

At present, three aspects of nearshore sediment transport are being investigated: 1) small-scale sediment transport, with emphasis on the initiation and vertical distribution of suspended sediment by turbulence and characterization of bottom boundary layer flows; 2) the linkage between small-scale sediment resuspension and large-scale flows (edge waves, shear waves and mean currents) which presumably lead to changes in nearshore morphology; and 3) large-scale morphology, with emphasis on the nearshore bathymetry of high energy, dissipative beaches in the Pacific Northwest.

APPROACH

The overall approach is to determine the fundamental relationships between fluid forcing and sediment response by conducting detailed field studies using instrumentation deployed within the surf zone. These measurements are used for direct sediment transport calculations, in addition to guiding development and evaluation of bottom boundary layer, fluid-sediment interaction models.

Instrumentation developed over the last several years has allowed better resolution of these bottom boundary layer processes. With the significant increase in sensor inventory from a DURIP grant, it is now possible to investigate considerably greater horizontal scales of sediment resuspension associated with large-scale flows, e.g., edge waves, shear waves and mean currents, through the use of lagged longshore arrays of instruments.

A new mobile survey system has been developed to rapidly measure nearshore bathymetry, providing the capability to conduct field investigations at a wide variety of beach sites.

WORK COMPLETED

Our recent tasks have included instrument development and several field studies. A Vertical Electromagnetic current Meter Array (VEMA) for use in studying velocity profiles in the bottom boundary layer was brought from the prototype stage to actual field instrumentation. The array is comprised of 4 2-component (u,v) sensors located at z=4, 10, 24 and 36 cm above the bed. A companion probe, the Fiber Optic Backscatter Sensor (FOBS) measures suspended sediment

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concentration at 19 elevations in the lower 50 cm of the water column. The lower eight sensors are spaced 1 cm in the vertical and indicate bed level fluctuations as they are alternately covered/uncovered by accretion/erosion, respectively. In conjunction with a pressure sensor to measure sea surface fluctuations, these instruments provide insight into the dynamics of sediment resuspension and transport in the wave-current bottom boundary layer.

In addition, we have recently developed the capability to measure nearshore bathymetry inside the surf zone. This bathymetry is the bottom boundary condition for large-scale fluid dynamics; attempts to understand fluid motions in the surf zone cannot proceed without knowledge of the bottom bathymetry. The new system utilizes a highly maneuverable, non-swampable watercraft (a.k.a. jet ski), differential GPS to establish horizontal position and a depth finder to measure water depth. Position and depth information are recorded by an onboard laptop computer at 1 Hz.

Three pairs of FOBS/VEMA and 6 additional packages, each comprised of an electromagnetic current meter, suspended sediment sensor and pressure sensor were deployed during a high energy experiment on the central Oregon coast in February, 1996. Foreshore and offshore surveys were conducted with the newly developed GPS based survey systems. Video camera's were used to collect wave runup data over a 1.6 km stretch of beach encompassing the array of in situ instrumentation.

In an investigation conducted during August, 1994, a vertical array of 5 hot-film anemometers and a FOBS were deployed from the Field Research Facility Pier. This investigation focused on bottom boundary layer turbulence and its role in the initiation and vertical distribution of suspended sediment.

RESULTS

Results from the analysis of the paired hot-film anemometers and suspended sediment study (5 paired sensors in the lower 5 cm of the water column) have clearly shown that; 1) nearbed fluid velocities in the wave bottom-boundary layer lead those higher in the flow, and; 2) suspended sediment concentration and high-frequency velocity fluctuation time-series are highly correlated and show considerable temporal variability as well as rapid decay with elevation above the bed. Results of a 1-dimensional analytic bottom-boundary layer model show similar velocity profiles to those observed and are being used to investigate a bottom boundary layer instability mechanism for the rapid, vertical resuspension of sediment from the sea bed. This data set and the subsequent analysis and modeling culminated in the Ph.D. dissertation of Diane Foster in 1996.

The wave runup data collected on the central Oregon coast during February, 1996 stand in strong contrast to the considerable archive of runup data currently available in the literature (Fig. 1). These runup data consist of swash elevation time series extracted from video recordings made using 3 cameras mounted on a headland located 2 km from the study site. Overlap in the coverage of the 3 cameras allowed for runup elevations to be analyzed over a 1.6 km stretch of beach. The significant vertical runup elevation was highly variable, and was found to be dependent on the foreshore beach slope. Runup motions were dominated by low frequency (infragravity) energy with peak periods of approximately 200 s. Incident band energy levels were 2-3 orders of magnitude lower than the infragravity peaks.

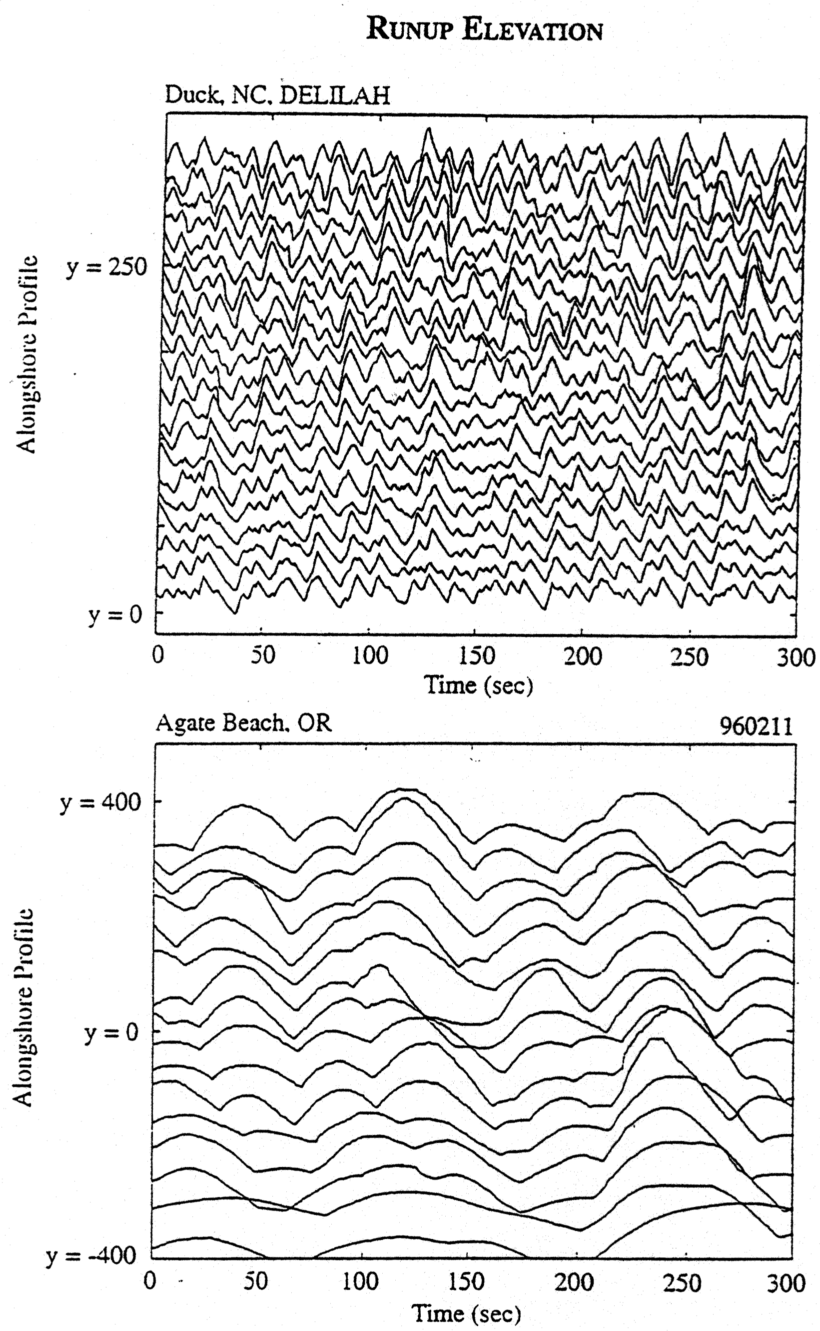

Figure 1. A 5 min time series of runup elevation as a function of longshore position; upper panel, Duck, NC, longshore range = 300 m; lower panel, Agate Beach, OR, longshore range = 800 m.

Figure 1 shows the strong contrast between runup elevations present on flat, high-energy Oregon beaches and the comparable motions on steeper, lower-energy beaches, such as Duck, NC. The combination of low-slope and large offshore waves results in the beaches of the Pacific Northwest having large cross-shore length scales with winter storm waves often breaking at distances greater than 1 km offshore. These large cross-shore length scales and the low-frequencies that dominate the inner surf zone result in large alongshore length scales as well.

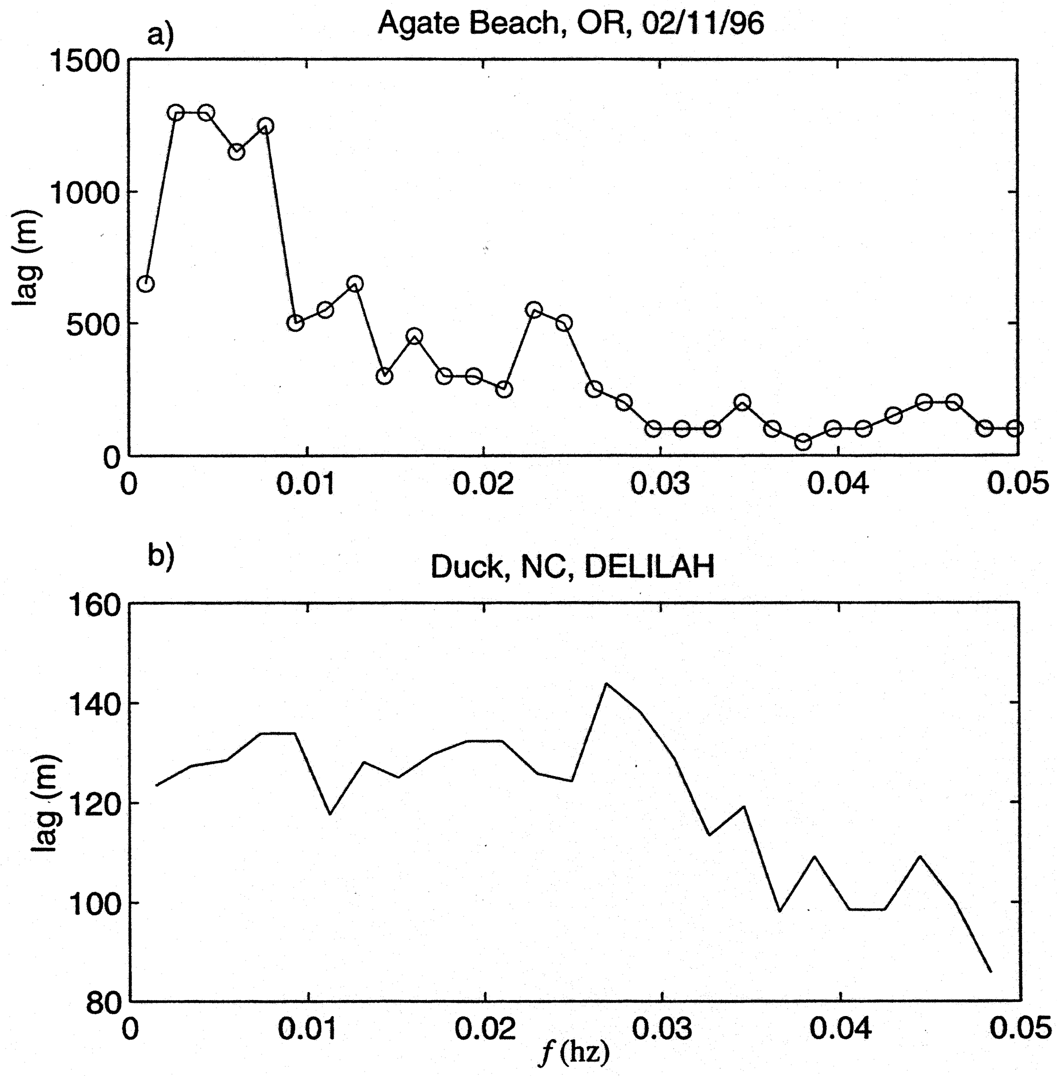

Figure 2. Alongshore runup coherence length scale as a function of runup frequency: upper panel, Agate Beach, OR; lower panel, Duck, NC.

Alongshore coherence length scales were (Duck, 1990) experiment following the methods of Holland (1995). Figure 2 indicates that runup on the Oregon coast is coherent over length scales of approximately 1 km or more, whereas the runup at Duck is coherent only over approximately 100 m. This data set and the subsequent analysis culminated in the Ph.D. dissertation of Peter Ruggiero in 1997.

IMPACT/APPLICATIONS

Development of a current meter array (VEMA) and suspended sediment sensor array (FOBS) has made possible the investigation of fluid-sediment interactions in the bottom boundary layer. Field experiments of the temporal and vertical scales of turbulence in the bottom boundary layer will provide insight into the initiation and vertical transfer of sediment from the sea bed to the lower and mid water column. A new, portable survey system will allow the investigation of nearshore bathymetry on larger

horizontal spatial scales and on a wider variety of beach types (from reflective to dissipative) than previously attainable. Field investigations on high-energy, dissipative beaches show strong contrast, in both fluid and sediment response, to the more commonly studied, lower-energy, steeper beaches typified by Duck, NC.

TRANSITIONS

The surf zone bathymetry survey system has been duplicated and is presently being used by the Littoral Remote Sensing program to provide ground-truth bathymetry measurements for wave-shoaling studies which attempt to infer bathymetry using video or other EO observations of surface wave shoaling characteristics (J. Dugan, Arete').

RELATED PROJECTS

We are participating with other ONR Coastal Dynamics PI's in the SandyDuck nearshore field experiment (Fall, 1997). Our in situ instrumentation deployment has been designed to provide synergy with the large-scale investigations and goals of the nearshore community.

REFERENCES

Holland, K.T. , 1995, "Foreshore Dynamics: Swash Motions and Topographic Interactions on Natural Beaches," Ph.D. Thesis, College of Oceanic and Atmospheric Sciences, Oregon State University, 119p.

Ruggiero, P., R. A. Beach and R. A. Holman, (in review), "Longshore Variability of Wave Runup on a High Energy, Dissipative Beach," JGR.

Ruggiero, P., P. D. Komar, W. G. McDougal and R. A. Beach (in review), "Wave Runup, Extreme Water Levels and the Erosion of Properties Backing Beaches," JGR.

Foster, D. L., R. A. Beach and R. A. Holman, (in revision), "Field Observations of the Wave Bottom Boundary Layer," JGR.

Beach, R. A. and R. W. Sternberg, (1996), "Suspended Sediment Transport in the Surf Zone: Response to Breaking Waves," CSR 16:15, 1989-2003.